PROJECT RECORD

EVALUATION

CONE COLLECTING EQUIPMENT

ED&T 1553
EQUIPMENT FOR CONE & SEED COLLECTION

DECEMBER 1971

U.S. Department of Agriculture
Forest Service
Equipment Development Center
Missoula, Montana

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EQUIPMENT FOR CONE AND SEED COLLECTION

By

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MECHANICAL ENGINEER

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Wynens, Jim	Forester, Georgia Forestry Commission

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ABSTRACT

Three types of collection devices were tested at the Arrowhead Slash Pine Seed Orchard near Macon, Georgia in September 1970. The three devices tested were the following:

1. The Ramacher model F-610P collector for picking cones up from the ground was tested by itself and in conjunction with the Ramacher R95TD sweeper.

2. The FABCO "Blue Bracero" roll-out sheet type collector was tested.

3. Two portable frames to be placed under the trees that were made especially for us by the Kewaunee Equipment Company were tested.

The Ramacher model F-610P collector used by itself was not successful. The Ramacher collector used in combination with the Ramacher sweeper was the fastest of all the collectors tested, both in terms of trees per hour and trees per man-hour. The "Blue Bracero" collector proved to be successful in delivering nearly all of the cones harvested by the shaker to a collecting box and to not slow the harvesting operation significantly. The portable frames were heavy and awkward and seemed to have application only for certain specialized applications, described in the conclusions section of this report. Operating costs, computed on the basis of assumptions described in the report, are lowest for the Ramacher collector and sweeper. The FABCO "Blue Bracero" cost nearly twice as much to use because of the increased labor requirement. The portable frames were the most costly to operate. The Ramacher and FABCO collectors collect the cones more economically than the labor crews do at present, but the portable frames are more costly to use than are the labor crews.

I. INTRODUCTION

A. Purpose

The purpose of this project was to design or develop a more economical system to collect pine cones in conjunction with the Brandt "Shock-Wave Shaker" and the Gould "Vibro-Shock" harvester in the seed orchards of the Southeast. The method presently used is pick up the cones by hand and load them into trucks. Since other areas of the United States may eventually obtain their seed from similar orchards, the results of this investigation will also be of interest outside the Southeast.

B. Scope

A design analysis of equipment for cone collection was performed in February 1970. Slash pine, longleaf pine, loblolly pine, and shortleaf pine were originally considered in three types of terrain, natural stands, seed production areas, and seed orchards. The cone harvesting season is only a few weeks long; so it would have been very difficult to test equipment in all three kinds of areas. Nearly all the seed obtained in this region is expected to eventually be harvested from orchards, and because of the lead time normally associated with adopting new equipment, it seemed appropriate to consider only seed orchards.

There are quite a number of manufacturers that supply collecting equipment to the fruit and nut industry. The evaluation of representative specimens of collectors already available had two favorable points:

1. If one or more of the collectors already available should prove to be suitable for collecting pine cones the cost of designing a machine from scratch would be saved.

2. If all types of devices now available were found to be unsuitable for collecting pine cones, much information needed for designing a suitable machine would be obtained.

The Arrowhead Seed Orchard in Macon, Georgia was made available to us by the Georgia State Forestry Commission; it was decided to test and evaluate harvesting equipment on slash pine at this location. Since the physical characteristics of longleaf pine and loblolly pine cones are not very different from those of slash pine, the data obtained here should be applicable to these three species of pine cones harvested with shakers. The shortleaf pine cones are much smaller than the other three, so the data obtained here may or may not apply to this species.

C. Plan of Development of Report

This report covers the present method of harvesting and collecting cones. Mention of the processing is made, but only to the extent that processing is affected by harvesting and collecting. An analysis of possible collecting techniques, a description of the conditions that existed during our tests, a description of the equipment tested, the test data and analysis of the data, conclusions, and recommendations are presented.

II. PRESENT METHOD OF HARVESTING AND COLLECTING CONES

DEFINITIONS

Some difficulty and confusion in terminology was encountered in preparing material for this report. Specific non-ambiguous terms to describe the operation of dislodging the cones from trees and the related operation of placing the cones in suitable containers are not in popular usage. It seems to be necessary to select words in general usage and assign them more restrictive meanings for the purpose of this report. This is probably a more desirable course than coining new words. For use in this report, "harvest" and "collection" will be defined as follows:

Harvest - The process or operation of removal or dislodgement of cones from a tree.

Harvester - A machine intended for harvesting, popularly known as a shaker.

Collection - The process or operation of getting the cones into a suitable container or vehicle after harvesting.

Collector - A device or machine intended to be used for all or part of the process or operation of collection.

It is true that the usage defined here is contradictory to usage in some trade literature. An example is the collection device known as the "Halsey Harvester". No existing system of nomenclature is readily apparent that will be compatible with all popular trade names and terms.

Methods described here are used for harvesting and collecting cones at the Arrowhead Slash Seed Orchard. Similar methods are used at other seed orchards with slight variations.

A. Harvesting Cones

Orchard Machinery Company's "Shock Wave Shaker" and Gould Brothers "Vibro-Shock" shakers are generally used for harvesting slash and longleaf pine in the seed orchards of the Southeast. Each harvester

requires one operator. The periodic maintenance required is relatively minor, so the operator usually lubricates, refuels, and performs other minor service operations himself.

The rate at which trees in a seed orchard can be harvested with the "Shock Wave" or "Vibro-Shock" shaker ranges from 30 to 150 trees per hour. The rate depends on terrain, tree size, tree spacing, skill of the operator, and whether the operator is paid by the hour or on a piece-work basis. At the Arrowhead Nursery, a harvester operator was timed at the rate of 33.4 trees per hour for 5 hours on September 19. At the same location on September 20, a harvest operator was timed at 72 trees per hour.

At the Arrowhead Seed Orchard in 1970, the "Shock Wave" shaker was followed by crews that removed any remaining cones by hand. The cones remaining on the trees amounted to about 10 to 15 percent of the total crop. The hand removal was an emergency measure that was used because of the great demand for seed in 1970.

B. Collecting Cones from Ground

Cone collection is generally done by hand in the Southeast. At the Arrowhead Slash Seed Orchard, crews of people are hired for the duration of the cone season for this task. A typical operation at the Arrowhead Orchard used 19 people; 15 laborers, one truck driver, one foreman, and two loaders. The foreman directs the operation, the 15 laborers pick up the cones off the ground and place them in 5-gallon (about 0.54 bushel) containers. When the 5-gallon containers are full or nearly so, the laborers empty them into containers of three bushel capacity. When the three-bushel containers are filled, the loaders empty them into a 2-ton truck.

In a typical operation, it was noted that this crew picked up and loaded 147.4 bushels of cones in 2 hours and 22 minutes. These cones come from about 480.0 trees over an area of about 144,000 square feet. The rate is 202.5 trees per hour and 62.2 bushels per hour. In terms of man-hours the rates are 10.66 trees per man-hour and 3.28 bushels per man-hour. No needles, limbs, or other foreign objects are loaded into the truck; the nurseries expect, and are set up to handle, clean cones. The laborers are paid $1.60 per hour; the loaders and truck drivers are paid $1.70 per hour, and the foreman $2.00 per hour. The truck costs $0.42 per hour, based on a use of 10 miles per day, 5 days per week at a rate of $44.00 per month plus $0.13 per mile. This makes the whole operation cost $31.52 per hour. In the typical operation observed, the cone collection cost was about $0.48 per bushel. This figure is only the cost of getting the cones off the ground and into the truck; it does not include the cost of harvesting the cones.

C. Processing of Cones at Nursery

The seed is extracted from the cones at a nursery. At present the nurseries receive only clean cones. At the Webster State Nursery near Olympia, Washington, the cost to extract seed from Douglas-fir cones is $2.00 per bushel. Mr. Homer Ward, a nurseryman there, estimates that the cost to extract seed from cones mixed with a small amount of trash would be about $2.15 per bushel; he estimates a cost of $2.40 per bushel for cones that are mixed with an amount of trash and sticks approaching 35 percent.

III. ANALYSIS OF POSSIBLE COLLECTING TECHNIQUES

Collecting devices can logically be divided into five basic types:

1. Portable frame to be placed on the ground.

   This type of device would probably be the cheapest to make and the simplest to use. However, a catcher of this type probably could not keep up with the shaker. It would not be economically feasible to slow the shaker to the rate of the catcher, so more than one catcher per shaker would probably be needed. It might be simpler to place the catcher at the tree after the shaker had fastened on to the tree, but this may slow the shaker too much. The Homelite Company sells such frames for use with cherries and these or similar frames may be useful with pine cones. The frame would have to be strong enough so that falling branches and tops would not damage it. Personnel should not be in the drop area during shaking.

2. Towed collector of roll-out sheet type.

   This type of collector is more complicated than the type 1, but should be easier to operate and more maneuverable. The vehicle used to tow the collector would not be available for other uses during the cone season. Most units now made of this type place the crop being collected into boxes.

3. Self-propelled collector of roll-out sheet type.

   This type of collector is generally more expensive than a type 2 collector of similar size and capacity. The self-propelled collector has the disadvantage that the motor for propulsion will be an expensive part of the collector and will sit idle through most of the year. Of course, this feature also insures that when the machine is wanted, it will be available, and a tow vehicle will not have to be obtained. In general, this type of collector is more maneuverable than the type 2 is.

4. Collector mounted on the harvester.

A collector mounted on the harvester seems to be very advantageous. However, in practice, this type of collector has not become very popular in the fruit and nut industry. Apparently there are problems involved in designing this type of machine that have not been solved with complete satisfaction yet.

5. Collectors for picking cones up from the ground.

This type of collector has the advantage of not having to keep right up with the harvester. How far behind the shaker this cone collection device may follow is not known at present. If squirrels and other unknown threats to cones will permit the cones to lie on the ground for an indefinite period of time, fewer collection devices than shakers may be needed. Here, too, a bagging device can be mounted on the collection device.

The amount of lead time available between the start of this project and the cone season was marginal for the design and manufacture of new articles. Commercial production equipment of the types described under 1, 2, and 5 were available to us for purchase or rental, so it was decided to test these. About the only performance advantage of a type 3 over a type 2 is increased maneuverability, so if the type 2 is satisfactory, the type 3 should be also. The problem of interchangeability between the "Shock Wave" and "Vibro-Shock" harvesters seemed to overly complicate the use of the type 4 collector.

The type 1 collector, the portable frame, is available on the general market only in the form of small, light units intended for use in cherry orchards. We had two types of sets designed and built especially for our test by the Kewaunee Equipment Company, Kewaunee, Wisconsin. The type 2 collector is marketed by several companies in the form of a towed unit with a sheet that is unrolled and rolled up in the manner of a powered window shade. The FABCO Division of the Kelsey-Hayes Company, Oakland, California, makes such a machine that is known as the "Blue Bracero". MEDC was able to rent a "Blue Bracero" from Arthur Hamlin, the FABCO dealer in Glenn, Michigan.

Type 5 collectors are available on the market; but not nearly in as great a profusion as are the types 2 and 3. A type 5 collector made by the Ramacher Company, Linden, California was available to us for rent by George Nunn and Son of Perry, Georgia. It is notable that only the type 5 collector, the machine for picking cones off the ground, is completely independent of the harvester. No interface is required between the harvester and the collector; the collector can pick up the cones anytime between immediately after and, probably, a day after harvesting. Short mechanical breakdowns affect only the machine experiencing the breakdown.

IV. TEST CONDITIONS

The test was conducted at the Arrowhead Slash Pine Seed Orchard, Macon, Georgia, from September 15 through September 23, 1970. Normal cone harvest was being conducted by Georgia State Forestry Commission crews concurrently with the tests.

The Arrowhead Slash Pine Seed Orchard is about 25 miles south of Macon, Georgia. The terrain is mostly flat with a very slight slope in one part of it. A diagram of the orchard is shown in Figure 1. The ground cover in some places is ankle high grass; in the remaining areas the ground is covered with 1 to 2 inches of pine needles. The trees are spaced 15 feet apart in rows 15 feet apart. The rows of trees are arranged in blocks 20 rows wide and 20 trees long. As the trees grow larger the blocks will be thinned to about 200 trees per block. At the time of the test, the trees had an average dbh of 9.44 inches, an average height of 35 feet, an average crown diameter of 19 feet, and an average crown height of 27 feet. The trees bore 0.31 bushel of cones per tree, on the average. A typical mixture of cones from various heredity groups at the Arrowhead Slash Pine Seed Orchard averaged 186 cones to the bushel. Some samples checked by other personnel at the orchard averaged 170 cones per bushel. The cones in the first mixture averaged 88.5 grams (3.12 ounces) in weight and 4.725 inches long by 1.575 inches in width.

The weather during the test was generally sunny with temperatures getting into the 80's and 90's every day and humidity quite high. The needle straw on the ground at most locations was moist in the morning from dew or light rain, but would dry out by noon. The dampness of the needle straw had an effect on the operation of the collecting equipment, as will be pointed out in the description of the performance of the collection devices.

V. DESCRIPTION OF EQUIPMENT

The equipment described herein was tested and evaluated in Georgia. There are other collectors on the market that are generally similar to one or another of these. The pick-up collector and the sweeper made by the Ramacher Equipment Company will be described together since they are intended to be used together and were used together when tested.

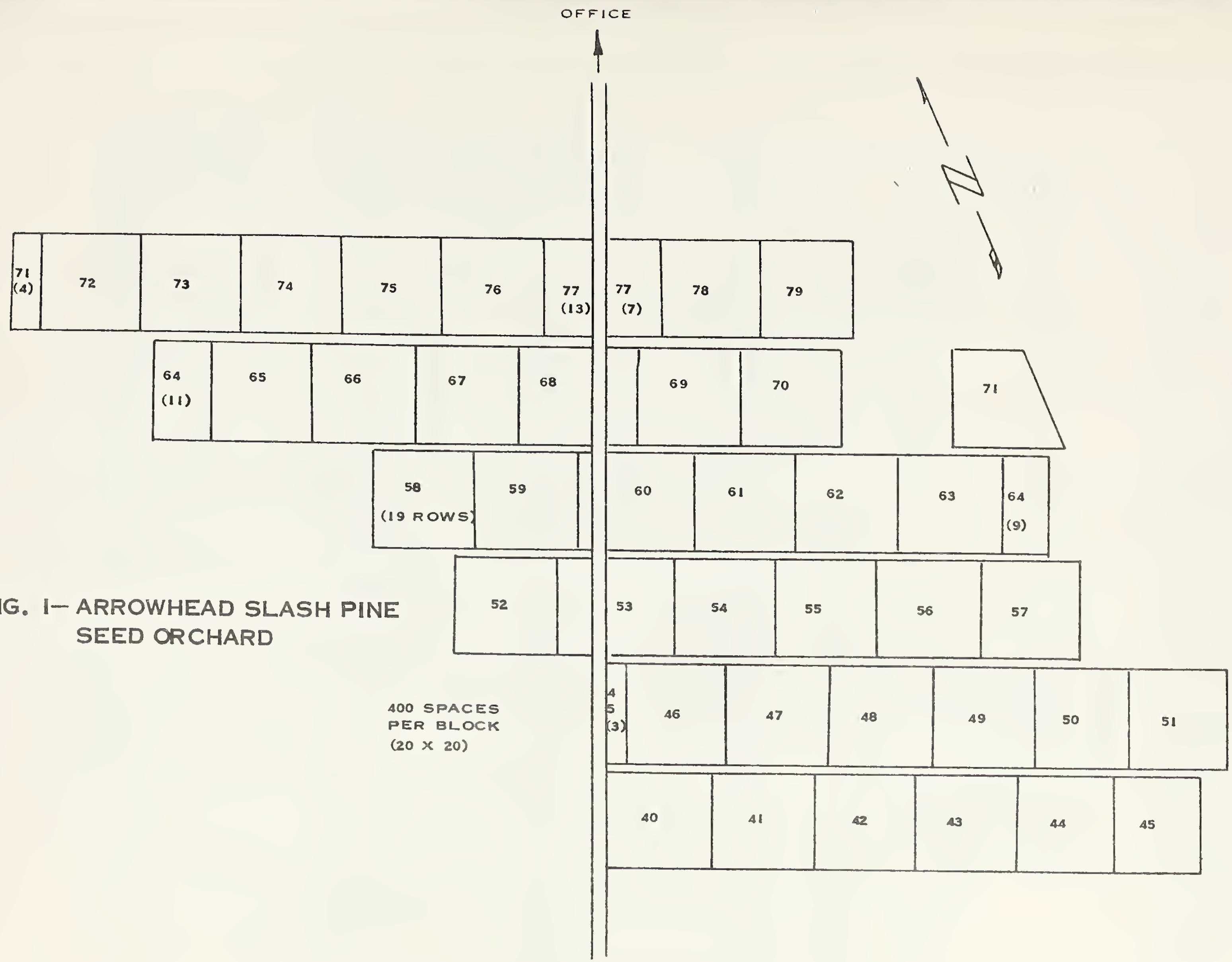


FIG. I— ARROWHEAD SLASH PINE SEED ORCHARD

A. Pick-up Collector

The pick-up collector made by the Ramacher Equipment Company was used in conjunction with a sweeper, also made by Ramacher. The sweeper is shown in Figure 2. The pick-up machine is shown in Figures 3, 4, and 5. The specifications of the collector and sweeper are as follows:

Collector	Sweeper
Model No.: F-610P	Model No.: R95TD
Length: 21'10" without trailer	Length: 115-1/2"
Width: 9'8"	Width: 76"
Wheelbase: 8'3"	Wheelbase: 52"
Weight: 6,620 lbs.	Weight: 1,000 lbs.
Picking Swath: 6'10"	Sweeping Swath: 62-1/2"
Cost: $13,231 f.o.b. factory	Cost: $2,500 f.o.b. factory

A schematic diagram of the Ramacher F-610P is shown in Figure 6. The mode of operation of the collector can be seen in the illustration.

A trailer is pulled behind the F-610P collector which receives the cones that are picked up by the collector. Trailers of various configurations are adaptable to the F-610P collector; the one provided by George Nunn and Son with the collector measured about 5 feet long from the hitch to the rear of the box. This trailer proved to well complement the collector and to not interfere with maneuvering. This trailer can be seen in Figure 4.

In use, the cones can either be picked up by the collector from where they fall on the ground, or they can be swept by the sweeper into windrows between the rows of trees and then be picked up by the collector.

B. Pull-out Sheet Collector

The "Blue Bracero" pull-out sheet collector made by the FABCO Division of the Kelsey Hayes Company was used in this test. This collector is shown in Figures 7, 8, and 9. The specifications of this collector are as follows:

Model: CV-5-24
Length: 41 feet
Width: 48 inches
Hitch to axle length: 27 feet
Weight: 4,200 lbs.
Catching area: 30'x30'
Cost: $4,580 f.o.b. factory

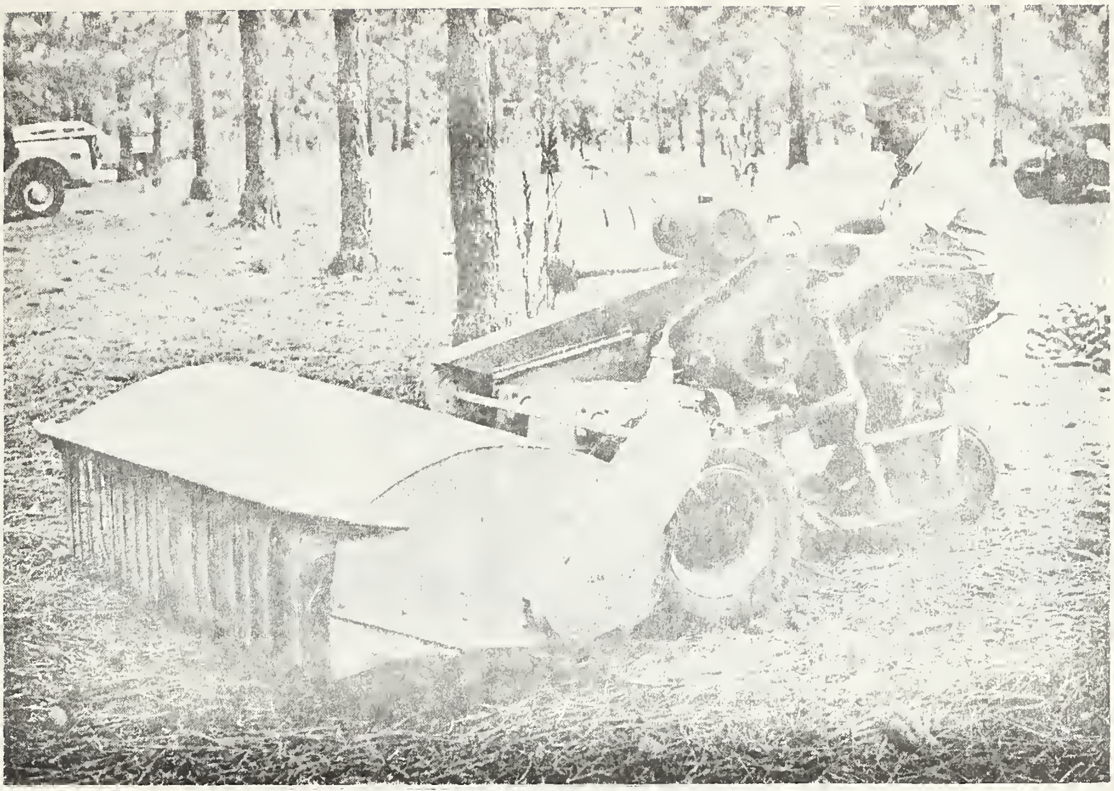


Figure 2.--Ramacher Model R95TD Sweeper.

Figure 3.--Front view of Ramacher F-610P collector.

Figure 4.--Left side view of Ramacher F-610P collector shown with trailer.

Figure 5.--Right side view of Ramacher F-610P collector just after emptying trailer.

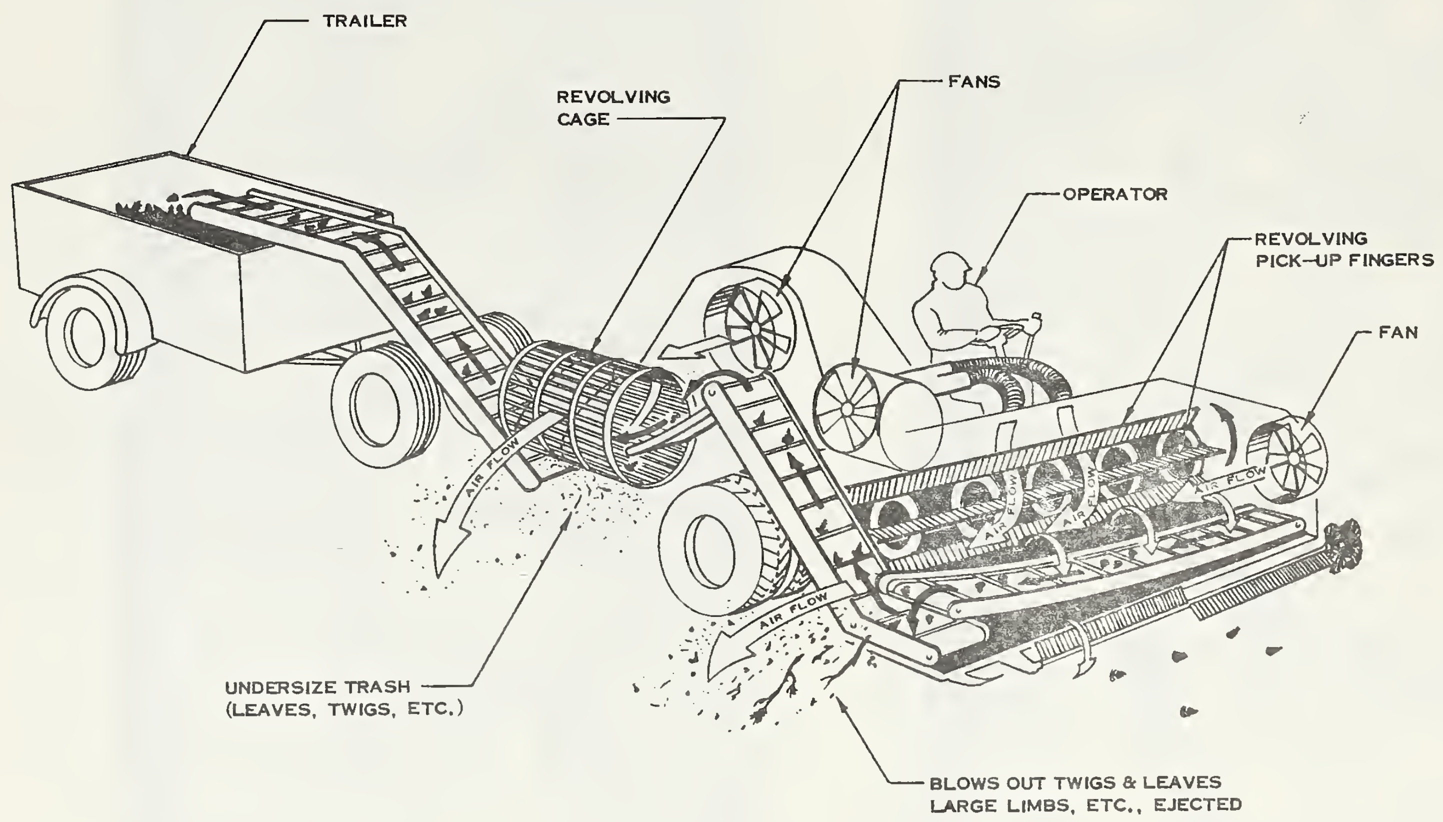


FIG. 6 – SCHEMATIC DIAGRAM OF THE RAMACHER COLLECTOR

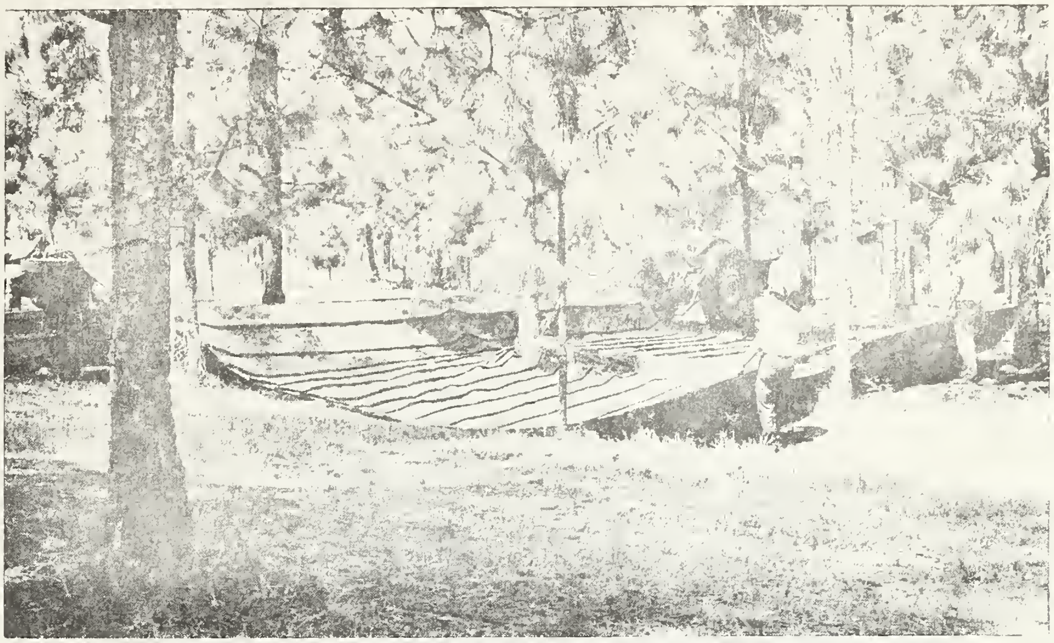


Figure 7.--"Blue Bracero" collector showing sheets being pulled out.

Figure 8.--"Blue Bracero" collector showing sheets being wound in.

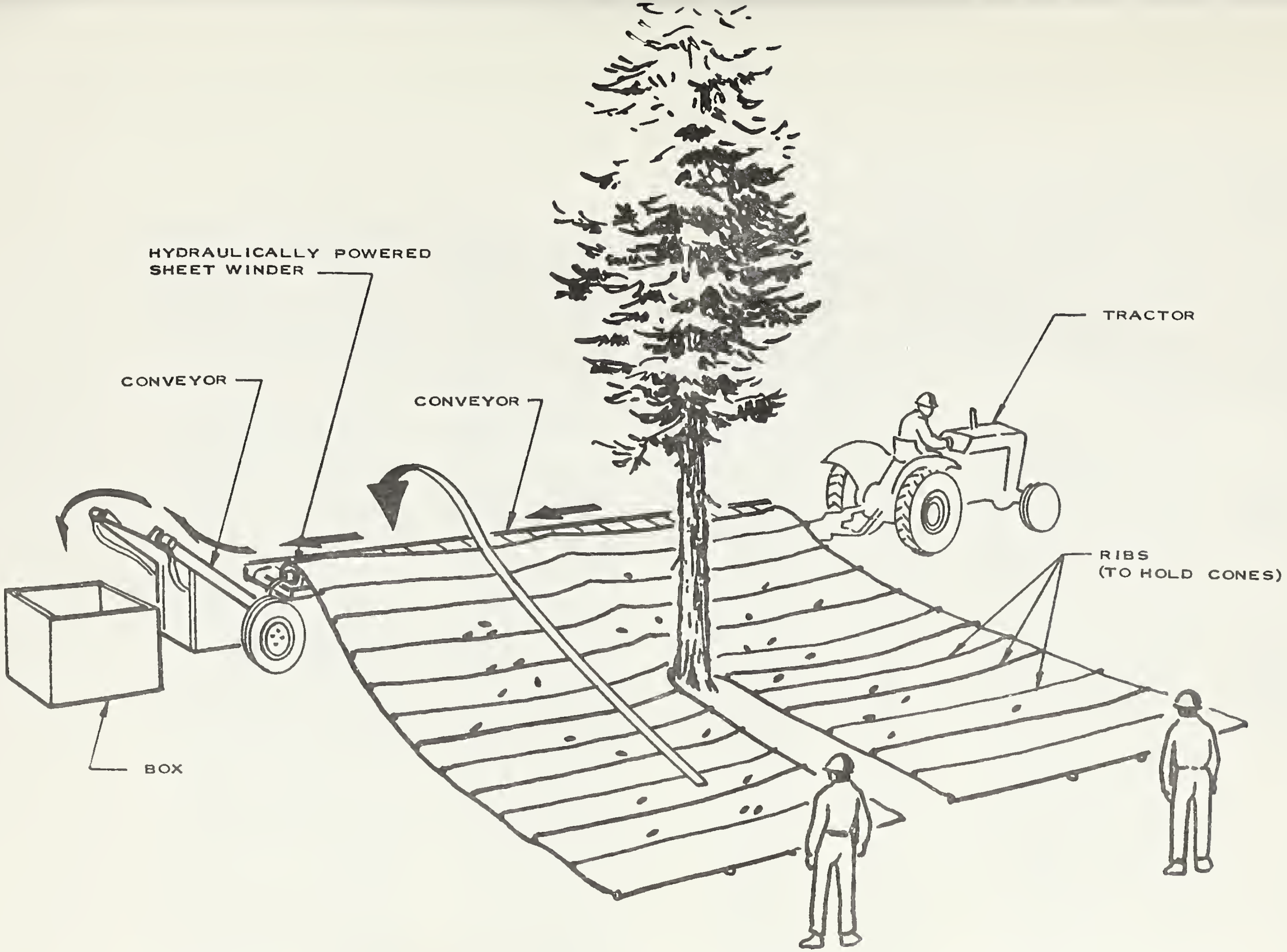


FIG. 9 — DIAGRAM OF FABCO "BLUE BRACERO" COLLECTOR

The tractor used to pull this machine must provide a minimum of 24 hp at the power-take-off. It is desirable that the tractor feature "live-power" that is, that the PTO be on regardless of whether the clutch is engaged or disengaged.

In operation, two men pull the sheet or "window shade" out around the tree to be harvested and collected, as shown in Figure 7. After the harvester shakes the cones out of the tree onto the sheet, the sheet is wound up by hydraulically driven motors. Ribs on the sheet keep the cones from falling off; the cones are dumped onto a conveyor belt that takes the cones to the rear end of the collector and dumps them in a box. In Figure 8, the sheet is being wound in from the left side of the picture. Figure 9 is a schematic showing how the cones are moved from the sheet to a collection box.

C. Portable Frames

Two types of portable frames were designed, built, and tested:

1. Drive-over frame

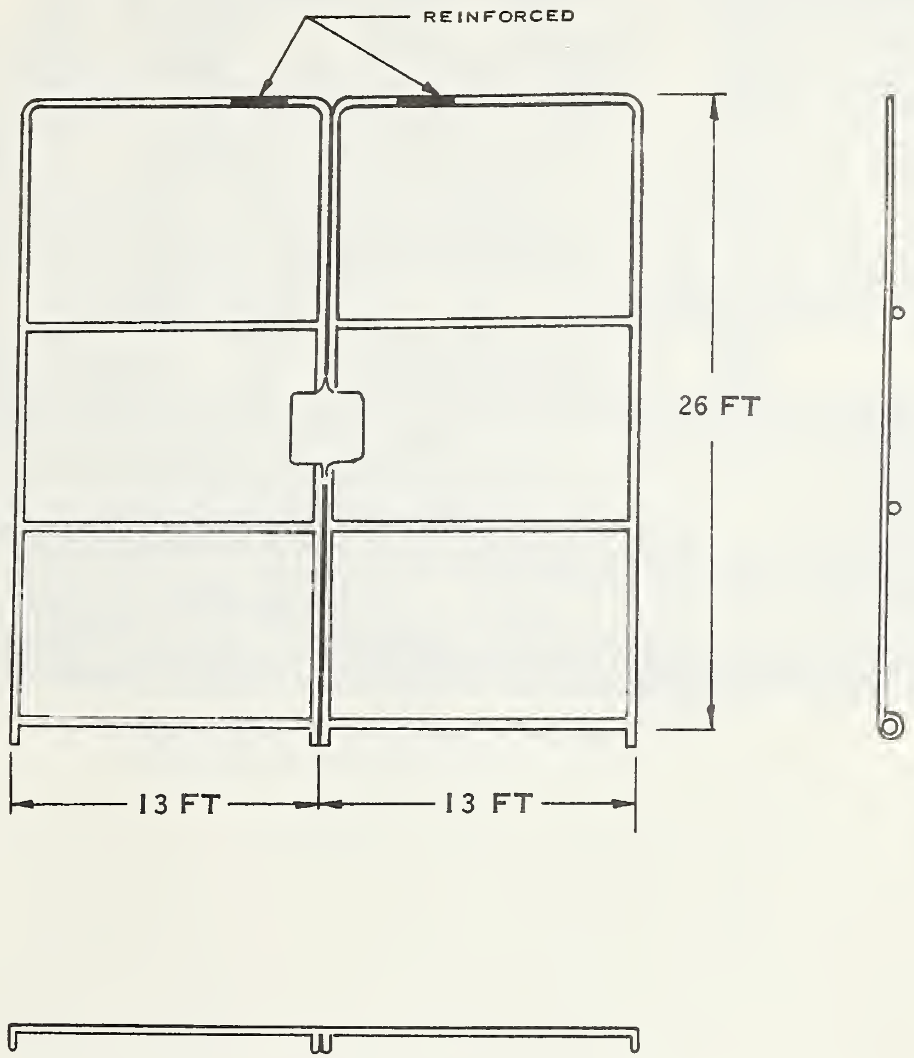
The drive-over frame is shown in Figures 10 and 11. This frame has two specially reinforced places for the shaker to drive over to get to the tree.

2. Drive-into frame

The drive-into frame is shown in Figures 12 and 13. This frame has an opening to permit the shaker to drive in. The opening would not be necessary if it was always used with the Gould harvester as this harvester can reach the tree from over 13 feet away. The A-frame shown in Figure 11 is necessary to cover the opening to prevent cone loss when the frame is built to accommodate the Shock Wave Shaker, as this example was.

These frames were used in a similar manner; they were carried by four laborers to the tree to be harvested. The Shock Wave or Vibro-Shock harvester then approaches the tree and shakes the cones loose. The Vibro-Shock shaker can reach the tree from over 13 feet away, but the Shock-Wave shaker has to drive over the drive-over frame or into the opening of the drive-into frame. An A-frame is provided to cover the tractor while it is in the opening of the drive-into frame. The A-frame may be mounted on the shaker if any great number of trees are to harvested and collected.

Figure 10.--Drive-over frame shown with
Vibro-Shock harvester.



NOTES–

STEEL FRAME OF 2 INCH ELECTRIC WELDED STEEL TUBING, REINFORCED AS SHOWN (LOCATION WHERE TRACTOR DRIVES OVER)

POLYPROPYLENE CLOTH

DUMP–OFF ENDS

FIG. II – DIMENSIONS AND SPECIFICATIONS OF DRIVE–OVER FRAMES

Figure 12.--Drive-into frame shown with Vibro-Shock harvester.

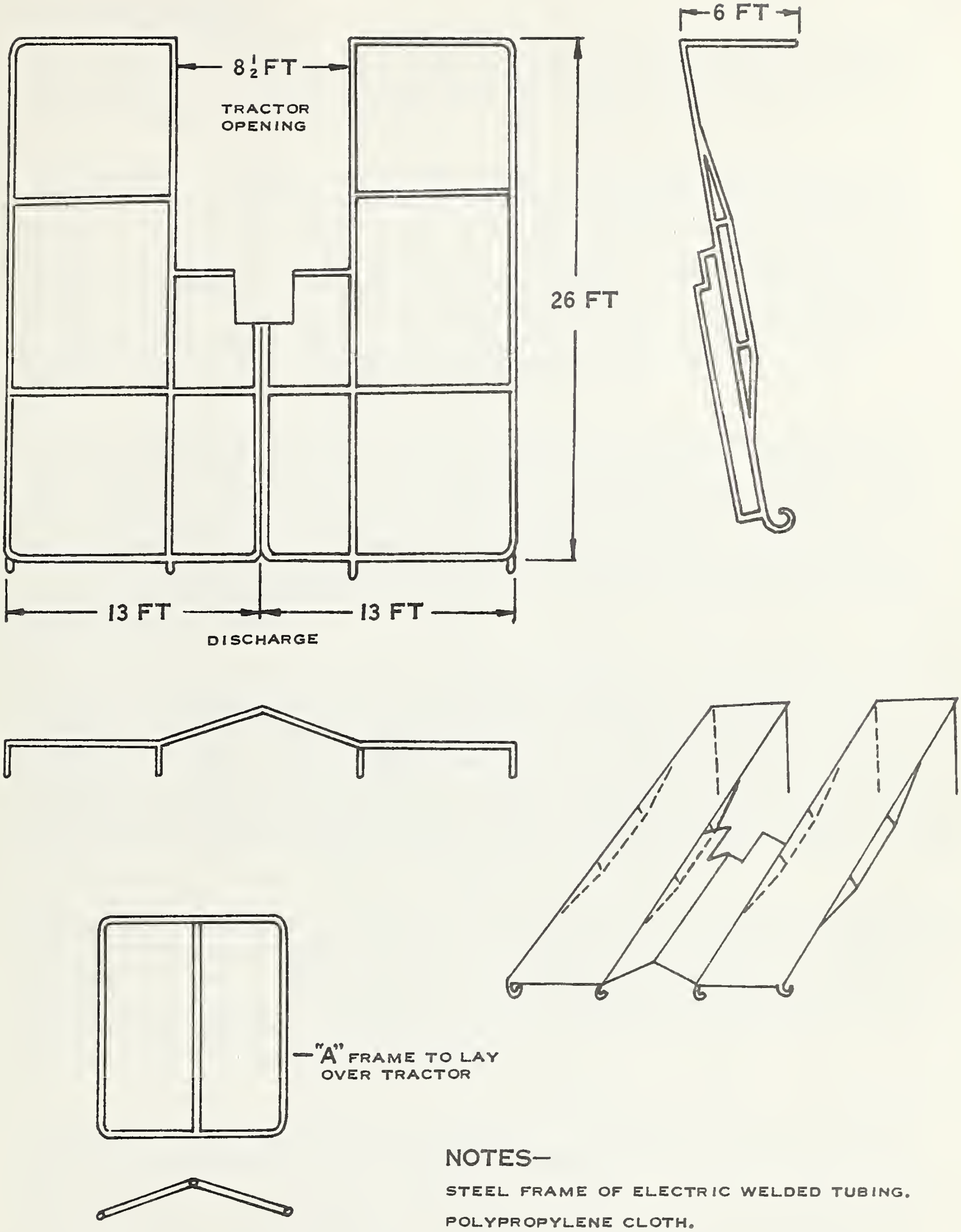


FIG. 13— DIMENSIONS AND SPECIFICATIONS OF DRIVE—INTO FRAMES

VI. DATA AND ANALYSIS

The production data obtained from this test are presented in tabular form in Figure 14. The tabular form was chosen to permit easy comparisons between collectors.

The Ramacher F-610P collector was tried by itself and with the R95TD sweeper. The collector used by itself was completely unsatisfactory. Trying to maneuver in such a way as to get as many cones as possible caused the machine to be slowed down excessively and still only 60 percent of the cones on the ground were collected. The testing of the F-610P collector by itself was abandoned because of the low percentage of cones that were picked up. The results of three tests of the Ramacher F-610P used to pick up cones swept into windrows by the R95TD sweeper are presented in Figure 14.

It can be noted in Figure 14 that in damp weather one man alternately operating a Ramacher sweeper and collector can collect cones at the same rate as one harvester can shake the cones out of the tree. When the ground cover is dry, one man alternately operating a Ramacher sweeper and collector can keep up with two harvesters. The cones are in a trailer which may then be hitched to a pickup truck for towing to a delivery point if the delivery point is more than a mile or so from the collection site.

The FABCO collector used with a harvester harvests and collects cones at about the same rate that the harvester alone will operate. One collector per harvester is needed because both must be at the same tree at the same time. Depending on the size of the harvest, two to four people per two collectors will be needed to remove full boxes of cones and replace them with empty boxes. These same people can load these boxes onto a truck that would be needed to bring the empty boxes to the collection site and to haul the cones to the nursery.

The portable frames are rather slow to move and it does not seem possible to use these in any number without slowing the harvester to a maximum of 60 trees per hour. This rate could be achieved by using two sets of frames per harvester. Using more sets of frames per harvester will not speed up the harvester because the distance that the frames have to be carried between trees will be longer.

The calculations and assumptions used to obtain the cost data presented in Figure 14 are presented in Appendix 2. It should be kept in mind that the cost figures are not directly comparable. For example, the hand pick-up crews load the cones into a 2-ton truck while the Ramacher collector loads the cones into a trailer. The trailer's capacity is much less than that of the truck, so it will need to be unloaded more frequently than will the 2-ton truck. The "Blue Bracero" loads the cones into a box. The optimum size box to use with this machine has not been determined, but physical limitations prohibit using a box

TEST	EQUIPMENT TESTED	CREW	SIZE OF PLOT	NUMBER OF TREES	TIME REQUIRED	PRODUCTION RATE TREES/HOUR	PRODUCTION RATE TREES/MAN HOUR	MACHINE COST*	LABOR COST*	TOTAL COST*	REMARKS
1	RAMACHER R95TD SWEEPER & RAMACHER F-610P COLLECTOR	ONE OPERATOR	7 ROWS WIDE X 40 ROWS LONG	249	0.83 HOURS SWEEPING, 1 HOUR PICKING UP, 1.83 HOURS TOTAL	138	138	$7.01	$3.62	$10.63	THE GROUND COVER CONSISTED OF A HEAVY LAYER OF DRY NEEDLES. ABOUT 95 PERCENT OF THE CONES ON THE GROUND WERE COLLECTED. THE FEW CONES LEFT ON THE GROUND WERE IN AREAS WHERE THE GROUND WAS UNEVEN.
2	RAMACHER R95TD SWEEPER & RAMACHER F-610P COLLECTOR	ONE OPERATOR	6 ROWS WIDE X 40 ROWS LONG	232	0.75 HOURS SWEEPING, 1.22 HOURS PICKING UP, 1.97 HOURS TOTAL	127	127	7.62	3.94	11.56	THE GROUND COVER CONSISTED OF A HEAVY LAYER OF WET NEEDLES. ABOUT 90 PERCENT OF THE CONES ON THE GROUND WERE COLLECTED. THIS TEST PROBABLY REPRESENTS THE WORST PERFORMANCE OF THE RAMACHER COLLECTOR AND SWEEPER. THE WET NEEDLES FREQUENTLY PLUGGED UP THE MACHINE AND HAD TO BE REMOVED BY THE OPERATOR.
3	RAMACHER R95TD SWEEPER & RAMACHER F-610P COLLECTOR	ONE OPERATOR	4 ROWS WIDE X 60 ROWS LONG	231	0.45 HOURS SWEEPING, 0.45 HOURS PICKING UP, 0.90 HOURS TOTAL	257	257	3.77	1.95	5.72	THE GROUND COVER HERE WAS SIMILAR TO THAT IN TEST 2, EXCEPT THE NEEDLES HAD BEEN DRIED BY THE SUN. THE COLLECTOR WAS ADJUSTED VERY CAREFULLY TO MATCH THE TERRAIN. VERY NEARLY ALL THE CONES ON THE GROUND WERE COLLECTED.
4	FABCO BLUE BRACERO MODEL	3 MAN CREW	7 ROWS WIDE X 40 ROWS LONG	269	1.85 HOURS	145	48	5.83	5.65	11.48	THIS DEVICE DELIVERS CONES TO A BOX IN ABOUT THE SAME CONDITION AS THE CONES ARE DELIVERED TO THE TRAILER BY THE RAMACHER MACHINE
5	DRIVE-OVER PORTABLE FRAMES	4 MAN CREW		13	0.50 HOURS	26	6.5	2.27	24.62	26.89	THESE FRAMES WERE SOMEWHAT HEAVY, BUT SEEMED TO BE WITHIN THE CAPABILITY OF FIELD MEN. BOTH OF THE FRAMES WERE BROKEN AT THE OPENING FOR THE TREE TRUNK AFTER SIX TREES WERE HARVESTED. THE TEST WAS TERMINATED AFTER 13 TREES WERE HARVESTED AND COLLECTED TO PREVENT FURTHER DAMAGE THAT MIGHT MAKE THE FRAMES UNSERVICEABLE FOR THE DEMONSTRATION TO FOLLOW.
6	DRIVE-IN PORTABLE FRAMES	5 MAN CREW		19	0.50 HOURS	38	7.6	2.00	21.05	23.05	THE CREW WAS TOTALLY EXHAUSTED AFTER 19 TREES BECAUSE OF THE EXCESSIVE WEIGHT OF THE FRAMES. ABOUT 15 PERCENT OF THE CONES THAT HIT THE COLLECTOR BOUNCED OFF.
	HAND COLLECTING	19 MAN CREW		480	2.36 HOURS	202.5	10.66	0.20	15.36	15.56	

* PER HUNDRED TREES COLLECTED

Fig. 14 - Production Data From Collector Test

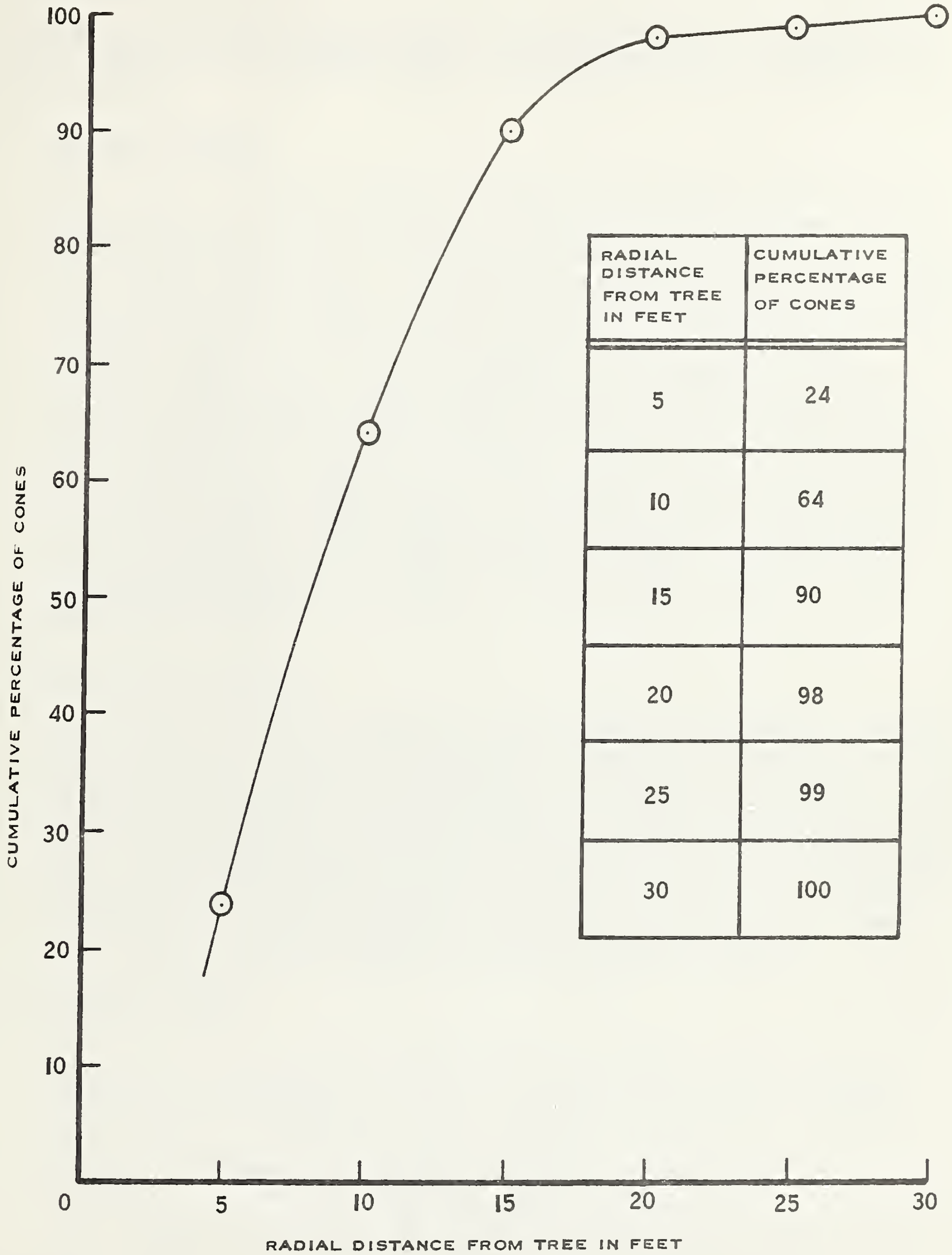
over 5 feet high by 6 feet wide and 3 feet deep which will require more frequent emptying than will the 2-ton truck. It would not have been fair to add the time required to empty the trailer or box into a 2-ton truck, either, because these boxes and trailers could have been handled in a variety of ways. For example, the trailer could be hitched to a pickup truck and hauled to the nursery.

Figure 15 shows the radial dispersion of the cones harvested with the Shock Wave shaker. This kind of data was not taken with the Gould shaker, but observation indicated that this harvester gave similar dispersions. These data indicate that if the trees get very much larger, a roll-up sheet harvester will have to be so large to get 90 percent or more of the cones, that maneuverability will be seriously impaired.

A demonstration of the collectors that were tested at Arrowhead was scheduled as a by-product of the test. A list of the representatives from companies and Government agencies that witnessed the demonstration follows:

Barris, Edgar Jr.	St. Regis	Lee, Fla.
Benson, Darrell A.	Eastern Tree Seed Lab	Macon, Ga.
Bond, D. L.	Continental Can Co.	Savannah, Ga.
Chappell, T. W.	U.S. Forest Service	Auburn, Ala.
Isaacs, William	Resource Operations	Birmingham, Ala.
Jones, LeRoy	U.S. Forest Service	Atlanta, Ga.
McElveen, C. A.	Buckeye Cellulose Corp.	Perry, Fla.
Mizell, Leroy	Buckeye Cellulose Corp.	Perry, Fla.
O'Gwynn, Claude	Southlands Exp. For., I.P. Co.	Bainbridge, Ga.
Roberts, J. W.	Continental Can Co.	Statesboro, Ga.
Rogers, Charley	St. Regis	Jacksonville, Fla.
VandaLinde, Frank	Brunswick Pulp & Paper	Brunswick, Ga.
Wynens, Jim	Georgia Forestry Commission	Macon, Ga.

The collectors that were production tested were demonstrated in the same manner and with the same techniques as when they were tested.



RADIAL DISTANCE FROM TREE IN FEET	CUMULATIVE PERCENTAGE OF CONES
5	24
10	64
15	90
20	98
25	99
30	100

FIG. 15— RADIAL DISPERSION OF CONES HARVESTED WITH THE SHOCK—WAVE SHAKER

VII. CONCLUSIONS

Conclusions that can be drawn about the collectors from data obtained in the tests at the Arrowhead Slash Seed Orchard will be presented in this section.

A. Ramacher Machine

This machine collects cones from trees in the seed orchard at the highest rate in terms of trees per man-hour of all devices tested. This machine also has the advantage of not requiring a direct interface with the harvester. The Ramacher machine did not quite separate out all the trash from the cones. The needle straw would give less trouble if the old needles were baled and removed before the cone season. A market for this old needle straw exists for use as a mulch for plants that prefer acidic soil. If the old needles were removed, the Ramacher machine would probably give the same production rate when the ground is damp as it did on dry ground in test No. 3, described in this report. There seems to be no practical way to separate short sticks (from 2 to 8 inches long) from the cones without drastically changing the machine. It is certain that suitable modifications can be made to this machine so that the only additional cleaning that needs to be done can be done by a fully automated process.

B. FABCO "Blue Bracero"

This machine collects cones at a rate equal to the fastest harvesting rates. The production per man-hour is greatly inferior to that of the Ramacher collector, but the "Blue Bracero" is cheaper to buy. The needles can very likely be completely separated from the cones by slightly modifying the blower presently used to blow light trash away. Sticks from 1 inch to 2 feet long will still go into the box along with the cones and must be removed elsewhere. It is likely that the cones can be made clean enough by the collector so that final cleaning can be done by a fully automated process.

C. Portable Frames

The drive-over frame did significantly slow down the harvesting operation. This device is lower in cost than the other equipment tested and offers some potential for small orchards that cannot afford the large capital outlay required by other cone collecting equipment. A serious drawback to the use of this frame is the way the cones are left at the end of the harvesting and collecting cycle; i.e., strung out in a row on the ground about 26 feet long and 10 inches wide with the needles shaken out of the tree mixed with the cones. The cones would still have to be picked up some way. If some economical method of getting these cones into a container could be found, and the frame reinforced around the tree opening, this device might be practical to use.

The drive-into frame seems to be hopeless because of excess weight and poor performance. It does not seem possible to correct the serious shortcomings of excess weight, of cones bouncing off the fabric, and of the difficulty of getting the cones raked down that do not roll down. This concept also has all the disadvantages of the drive-over frames in addition to its own particular disadvantages.

VIII. RECOMMENDATIONS

The tests reported here indicate that mechanized cone collection has advantages over manual collection. All the equipment and methods tested could be improved, however.

A. Pick-up Collector

The Ramacher Company should be consulted and their estimate of the cost to modify the machine to get rid of more of the trash obtained. Also the cost of baling the needle straw and the possible profit that can be obtained from the sale of the needle straw should be determined. If the machine can be improved or if the needle straw can be baled and removed, collecting cones in wet weather would be faster and more efficient. The design features of other pick-up collectors should be studied to see if they might also work with pine cones.

B. Pull-out-Sheet Harvester

The "Blue Bracero" pull-out-sheet harvester can be improved so that more of the needle trash is blown away. The cost of such modification should be determined. The differences between the pull-out-sheet collector we tested and others on the market should be studied to see which of the others might also be useful for collecting pine cones.

C. Portable Frames

A study should be made to determine if there is a need for a device having the capability of the drive-over portable frames. This device seems to be feasible to use; the question is whether having the cones and needles in a pile 26 feet long and 10 inches wide is a worthwhile accomplishment or not. If this can be shown to be a worthwhile step in cone collecting, the drive-over frames should be redesigned to strengthen the frames around the opening for the tree, make them about 10 to 15 percent lighter, if possible, and use a more durable rope such as polypropylene for the lacing.

APPENDIXES

APPENDIX I

A list of manufacturers of collectors follows. The numbers after the company's name indicate the type of collector the company makes, according to the following code: (1) portable frame, (2) towed roll-out sheet type of collector, (3) self-propelled roll-out sheet, (4) collector mounted on harvester, or harvester mounted on collector, (5) pick-up collector:

Couberly Equipment Co., Biggs, California (5)
FABCO Division, Kelsey-Hayes Co., Oakland, California (2) (3) (4)
Goodwin Equipment Service, Manteca, California (5)
Gould Brothers, Inc., Milpitas, California (2) (3)
Halsey Harvester and Supply Co., Inc., Colusa, California (2) (3)
Homelite, Port Chester, New York (1)
Ingalls Manufacturing Co., Ceres, California (5)
Johnson Farm Machinery Co., Woodland, California (4)
Kewaunee Equipment Co., Kewaunee, Wisconsin (1)
Oneto Gotelli Co., Stockton, California (2)
Ramacher Manufacturing Co., Linden, California (5)
W. A. Gerrans Co., Meridian, California (2) (3)

APPENDIX II

The calculations and assumptions used to calculate the cost data presented in Section VI are presented here.

A. Ramacher Collector and Sweeper

These costs are computed with the assumption that the equipment will be used by private owners for 8 weeks per year and rented to the Forest Service for an additional 4 weeks per year. The machinery is assumed to be used 40 hours per week.

1. Fixed Ownership Costs

Depreciation $15,731 - $6,000 straight line 10 year	$973.10/yr
Replacement differential (assume cost increases to $20,000 in 10 yrs)	$426.90/yr
Total F.O.C.	$1,400.00/yr

2. Use Rate

Fuel, oil, adjustments, repairs, and similar costs	$5.00/hr
Management cost @ $6.00/week	$0.15/hr
Total Use Rate	$5.15/hr

3. Total Hourly Rate

The total rate is the sum of the fixed ownership rate, the use rate, and 20 percent profit.

Putting the fixed ownership rate on an hourly basis:

Hours per year = 12x40 = 480

$$\frac{\$1,400}{480} = \$2.92/\text{hour}$$

Total cost = $2.92 + $5.15 = $8.07/hour

plus 20% profit	= 1.61
Total Rate	$9.68/hour
Operator rate is	$5.00/hour

Multiplying these rates by 100 and dividing by trees per hour gives the cost to harvest 100 trees.

Machine cost:

Test 1 - $\frac{\$9.68}{138} \times 100 = \$7.01/100$ trees

Test 2 - $\frac{\$9.68}{127} \times 100 = \$7.62/100$ trees

Test 3 - $\frac{\$9.68}{257} \times 100 = \$3.77/100$ trees

Labor Cost:

Test 1 - $\frac{\$5.00}{138} \times 100 = \$3.62/100$ trees

Test 2 - $\frac{\$5.00}{127} \times 100 = \$3.94/100$ trees

Test 3 - $\frac{\$5.00}{257} \times 100 = \$1.95/100$ trees

B. FABCO "Blue Bracero"

These costs are calculated with the assumption that the machine will be used by a private owner for 8 weeks per year and rented to the Forest Service for an additional 4 weeks per year. The machine is assumed to be used 40 hours per week.

1. Fixed Ownership Costs

Depreciation from $4,580 to $1,000 in 10 yrs	$358/yr
Replacement differential (assume cost increases from $4,580 to $6,000 in 10 yrs)	$142/yr
Total F.O.C.	$500/yr

2. Use Rate

It is assumed here that a tractor to pull the collector is available this season from other duties.

Tractor cost	\$5.00/hr
Adjustments, repairs, maintenance	\$1.00/hr
Use Rate	\$6.00/hr

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3. Total Hourly Rate

The total rate is the sum of the fixed ownership rate, the use rate, and 20 percent profit.

Putting the F.O.C. on a hourly basis:

Hours per year = 40x12 = 480

$\frac{\$500}{480} = \$1.04/\text{hour}$

Total cost = \$1.04 + \$6.00 = \$7.04/hour

plus 20% profit	1.41
Total rate	\$8.45

Labor cost =	1 tractor driver	\$5.00/hour
	2 laborers @ \$1.60/hr	3.20/hour
		\$8.20/hour

Multiplying these rates by 100 and dividing by trees per hour gives the cost to harvest 100 trees.

Machine cost:

Test 4 - $\frac{\$8.45}{145} \times 100 = \$5.83/100$ trees

Labor cost:

Test 4 - $\frac{\$8.20}{145} \times 100 = \$5.65/100$ trees

C. Drive-over Portable Frames

These costs are calculated with the assumption that the frames will be used by the Forest Service for 4 weeks per year. The frames are assumed to be used 40 hours per week.

1. Fixed Ownership Costs

Depreciation \$100 - 0 over 2 years	\$50/yr
Replacement differential (assume cost increased to \$108 in 2 yrs)	\$4/yr
Total F.O.C.	\$54/yr

2. Use Rate

Repairs	\$0.15/hr
Management	\$0.10/hr
Total Rate	\$0.25/hr

3. Total Hourly Rate

F.O.C. converted to hourly rate

$\frac{\$54}{160} = \$0.34/\text{hour}$

Total = \$0.34 + \$0.25 = \$0.59/hour

Labor cost: 4 laborers @ \$1.60/hour = \$6.40/hour

Multiplying these rates by 100 and dividing by trees per hour harvested gives the cost to harvest 100 trees.

Frame cost:

Test 5 - $\frac{\$0.59}{26} \times 100 = \$2.27/100$ trees

Labor cost:

Test 5 - $\frac{\$6.40}{26} \times 100 = \$24.62/100$ trees

D. Drive-into Portable Frames

These costs are calculated with the assumption that the frames will be used by the Forest Service for 4 weeks per year. The frames are assumed to be used 40 hours per week.

1. Fixed Ownership Costs

Depreciation \$150 - 0 over 2 years	\$75/yr
Replacement differential (assume cost increases to \$162 in 2 yrs)	\$6/yr
Total F.O.C.	\$81/yr

2. Use Rate

Repairs	\$0.15/hr
Management	\$0.10/hr
Total Rate	\$0.25/hr

3. Total Hourly Rate

F.O.C. converted to hourly

$\frac{\$81}{160} = \$0.51/\text{hour}$

Total = \$0.51 + \$0.25 = \$0.76/hour

Labor cost: 5 laborers @ \$1.60/hour = \$8.00/hour

Multiplying these rates by 100 and dividing by trees per hour harvested gives the cost to harvest 100 trees.

Frame cost:

Test 6 - $\frac{\$0.76}{38} \times 100 = \$2.00/100$ trees

Labor cost:

Test 6 - $\frac{\$8.00}{38} \times 100 = \$21.05/100$ trees

E. Hand Collection by Labor Crew

The labor crew presently used for cone collection at the Arrowhead Seed Orchard are organized as follows:

A typical operation uses 19 people; 15 laborers, one truck driver, one foreman, and two loaders. The cones are loaded into a 2-ton truck. The cost works out as follows:

Two loaders @ $1.70/hour =	$3.40/hr
One truck driver @ $1.70/hour =	$1.70/hr
One foreman @ $2.00/hour =	$2.00/hr
Fifteen laborers @ $1.60/hour =	$24.00/hr
Total Labor Cost	$31.10/hr

The truck costs $44.00 per month plus $0.13 per mile. Converting these figures to hourly rates based on 10 miles per day, 5 days a week:

$$\frac{\$44 \times 12}{52 \times 40} = \$0.25/\text{hour}$$

$$\frac{\$0.13 \times 10}{8} = \$0.16/\text{hour}$$

Total truck cost: $0.41/hour

Total Operation Costs: $31.52/hour

Multiplying these rates by 100 and dividing by trees per hour harvested gives the cost to harvest 100 trees.

Truck cost:

$$\frac{\$0.41}{2{,}025} \times 100 = \$0.20/100 \text{ trees}$$

Labor cost:

$$\frac{\$31.10}{2{,}025} \times 100 = \$15.36/100 \text{ trees}$$

Total cost:

$$\frac{\$31.52}{2{,}025} \times 100 = \$15.56/100 \text{ trees}$$